Alpine Entomology 2 2018, 15–34 | DOI 10.3897/alpento.2.22759

PENSOFT

Alpine Entomology

On the genus *Chaetocladius* s. str. Kieffer, 1911 from Switzerland with descriptions of five new relic species occurring in glacial alpine springs and streams (Diptera, Chironomidae)

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http://zoobank.org/A5359113-D999-4051-92B2-B048FEA8FC1F

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Received 4 December 2017
Accepted 29 January 2018
Published 2 March 2018

Academic editor:
Patrick Rohner

Key Words

Chironomidae
Orthocladiinae
new species
glacial streams
Swiss Alps
conservation

Abstract

A description of the male adults of five *Chaetocladius* s. str. species (*C. castellae* **sp. n.**, *C. lencioniae* **sp. n.**, *C. lodscrozetae* **sp. n.**, *C. macunensis* **sp. n**. and *C. muttensis* **sp. n.**) is provided based on material collected in some glacial alpine springs and cold streams located in the Swiss Alps (altitude 1800–2700 m). Male adult of the nearest *Chaetocladius* species known from Europe and neighbouring areas belong to: *C. aedeagolobatus* Rossaro, Magoga & Montagna, 2017; *C. insolitus* Caspers, 1987; *C. gracilis* Brundin 1956; *C. antipovae* Makarchenko & Makarchenko, 2011; *C. dissipatus* (Edwards, 1929), *C. holmgreni* (Jacobson, 1998), *C. egorych* Makarchenko & Makarchenko, 2017. Although some resemblance can be found between the five diagnosed and described species and other related members of the *Chaetocladius* genus, the taxonomic position cannot be clarified until current comprehensive work on the genus is complete. Geographical distribution of the five new species is currently restricted to the two Alpine Swiss glacial catchments: upper basins of the Rhône River and Muttbach streams; streams and lakes delimited by the Macun area. This highlights the importance of some high mountain ranges, considered as cold glacial enclaves and hotspots of endemism, in the preservation and persistence of autochthonous alpine relic species. Such species are considered as relevant biogeographic representative and their loss would be biologically indicative of global warming and climate change. Currently, there are only seven recorded *Chaetocladius* species from Switzerland: *C. coppai* Moubayed-Breil, 2017; *C. laminatus* Brundin, 1947; *C.* cf. *longivirgatus* Stur & Spies, 2011; *C. melaleucus* (Meigen, 1818); *C. perennis* (Meigen, 1830); *C. piger* (Goetghebuer, 1913); *C. suecicus* (Kieffer, 1916). Consequently, the description of the five new species increases the total number in the genus *Chaetocladius* to twelve for this country. Remarks and comments on the taxonomic position, ecology and geographical distribution of the new described species, with key to known male adults from the upper catchment of Rhône River (including Muttbach valley) are provided..

Introduction

Alpine freshwaters areas occurring in mountainous landscapes and high elevation are characterized by severe environment (Ward 1994). The relatively harsh environmental conditions prevailing, such as long winters, thick snow and ice cover, low temperature and limited water productivity, contribute to the settlement of highly specialized aquatic fauna (especially aquatic insects). Furthermore, the insular nature of alpine landscapes constrains the dispersal and distribution of species in reinforcing and maintaining high level of endemism. Alpine freshwater habitats thus harbour a plethora of highly specialized species that exhibit a comparably small distributional range, making them particularly susceptible to environmental change.

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The Chironomidae family (Diamesinae and Orthocladinae in particular) predominates in the high alpine ponds/lakes and stream network with a large number of species compared to the other macroinvertebrates such as other Diptera, Ephemeroptera, Plecoptera, Trichoptera, Oligochaeta (Milner and Petts 1994, Ilg et al. 2001, Lods-Crozet et al. 2001, Hieber et al. 2005, Robinson et al. 2007, 2016, Lods-Crozet et al. 2012). Most of the alpine studies in hydrobiology were focused on macroinvertebrates inhabiting glacial streams (Milner et al. 2001), which revealed that Chironomidae were predominant and characterized by cold adapted species (Kownacki et al. 2000; Lods-Crozet et al. 2001; Moubayed-Breil and Lods-Crozet 2016; Robinson et al. 2007, 2016; Moubayed-Breil and Dia 2017). Non-glacial aquatic systems, such as springs were also well represented in high alpine landscapes (Lencioni et al. 2012) but have not received much attention so far. High mountain rheocrenes located in the Swiss Alps mostly consist of sensitive and vulnerable habitats, which give shelter, refuge and sanctuary for populations and species potentially rich in divergent genetic lineages and thus resembling diversity hotspots of global significance (Monaghan et al. 2005). Some cold crenobiontic relic species were found in the pristine headwaters in the Alps including two new recently described species (*Chaetocladius coppai* Moubayed-Breil, 2017; *Heleniella helvetica* Moubayed-Breil & Lods-Crozet, 2016) from remote areas in small groundwater resurgences and spring-fed streams located in the upper basin of the Rhône River.

Based on knowledge provided on the taxonomy, geographical distribution and ecology of the known *Chaetocladius* species from Europe and the Palaearctic Region (Brundin 1947, 1956; Pankratova 1970; Sæther 1980, 1990; Caspers 1987, Cranston et al. 1989, Bhattacharyay et al. 1993, Lods-Crozet 1998, Moubayed 1989, Makarchenko and Makarchenko 2001, 2004, 2007, 2011a-b, Langton and Pinder 2007, Lencioni et al. 2007, 2012, Zelentsov 2007, Stur and Spies 2011, Ashe and O'Connor 2012, Kobayashi 2012, Wang et al. 2012, Sæther and Spies 2013, Makarchenko et al. 2017, Moubayed-Breil 2017, Rossaro et al. 2017), the genus *Chaetocladius* Kieffer, 1911 currently comprises worldwide about 79 valid species.

Based on material collected between 1997–1998 and 2013 in high alpine springs and small cold streams located in the Swiss Alps, we here describe five new species of *Chaetocladius* s. str for which we discuss the taxonomic position, ecology and geographical distribution. A key to the known male adults from the catchment of the upper Rhône (including Muttbach glacier), with remarks on some related species from the Palaearctic Region are also provided.

Material and methods

Study sites

Numerous sampling sites are located along some glacial streams and streamlets delimited by the three Alpine Swiss glacial catchments: - the Muttbach valley and the Rhône River alluvial plain "Gletschboden" in the Central Alps (46°34'12.258"N; 8°22'45.623"E); - the Macun streams and lakes in the Swiss National Park, Eastern Alps (46°43'39.678", 10°07'55.764"E).

The Mutt stream (length: 3600 m) originating from the Mutt glacier (area 0.6 km^2, altitude 2582–3000 m) represents the major tributary of the upper Rhône catchment. It joins the Rhône River at the upper limit of a floodplain and contributes approximately 10 % (0.62 $m^3.s^{-1}$ in 1997) to the Rhône discharge (Knispel and Castella 2003). The upper parts of the Mutt catchment are composed mainly of moraines and bare rocks including a carbonate outcrop. Alpine grasslands are found in the lower parts while *Salix* spp. and *Alnus viridis* thickets, together with herbaceous alpine vegetation, are predominant in the floodplain (Lods-Crozet et al. 2001).

The Rhône River alluvial plain "Gletschboden" is located in the upper catchment of the Rhône River. The major water source is the Rhône glacier (area 10.2 km^2). Below the glacier snout, situated at an altitude of 2210 m, the Rhône River flows down a 400 m high granite cliff (slope 63 %) and enters an alluvial plain (length: 2000 m). During the last century, the retreat of the Rhône glacier has left valley moraine deposits and a braided channel pattern. The upper part of the Rhône is a kryal segment (Ward 1994) where water temperature rarely exceeds 4 °C. Mean annual discharge of the Rhône in 1998 was 2.88 $m^3.s^{-1}$ and its hydrograph reveals a discharge peak in summer with large daily flow fluctuations (Knispel and Castella 2003). Highly diverse thickets of *Salix* spp. and *Alnus viridis* and herbaceous alpine vegetation are predominant in the alluvial plain, with some *Larix decidua*.

The Macun cirque site is a high alpine cirque (> 2600 m), which is located in the Eastern Alps (Swiss National Park). It was annexed to the park in 2000 and currently is an area designed for long-term monitoring of alpine water bodies (springs, streams, ponds, lakes). The region comprises more than 35 small lakes or permanent ponds and around 10 small temporary ponds scattered within two sub-basins. A north basin is fed mostly by snowmelt and groundwater, whereas the south basin is fed by glacial melt from a number of rock glaciers. Precipitation is low, typically being around 850 mm per year. Bedrock geology is crystalline (ortho-gneiss) rock. The area is above the tree line and the drainage area of each pond is characterised by a mixture of two types of land cover, rock and alpine grassland (Robinson and Oertli 2009, Lods-Crozet et al. 2012).

The sites in the Central Alps were investigated three times a year between 1996 and 1998, during the three major annual hydrological phases: in June during snowmelt, in August during ice melt and in September at low water level. The field protocols followed closely those established in the EU-project 'AASER' (Brittain and Milner 2001, Lods-Crozet et al. 2001, Knispel and Castella 2003, Lods-Crozet 2012).

Sampling procedure

Ten sampling points were chosen randomly within each site. Depth, flow velocity and bed sediment composition

were recorded at each of the 10 points before benthic sampling. The fauna was then collected into a 250-mm-mesh pond net at these points by kick sampling within a 30 × 30-cm area for 30 s. Adult material was collected using Malaise traps which were set up for a minimum of five days. In the Eastern Alps, during summer 2013, a supplementary survey was conducted to complete the standardized monitoring of small water bodies and streams within the Macun cirque (Lods-Crozet et al. 2012). Adult material of the five new described *Chaetocladius* species was collected for fifteen days using Malaise trap placed in the surrounding area of three lakes (altitude 1800–2700 m). Pupal exuviae were collected with a drift net from the shore.

All samples were preserved in 70 % Ethanol. Material of male adults were cleared of musculature in 90 % lactic acid (head, thorax, abdomen and anal segment) for about 60 to 80 minutes, which can be left overnight at room temperature without any detrimental effect or damage. The specimens were checked under a binocular microscope after 20 minutes in lactic acid to determine how the clearing was progressing. When clearing was complete the specimens were washed in two changes of 70 % Ethanol to ensure that all traces of lactic acid were removed. Compared to clearing with potassium hydroxide, or other clearing solutions, no deterioration of the typical "original" structure is reported by using lactic acid. All examined material was mounted in polyvinyl lactophenol, remaining material including paratypes were preserved in 70 % Ethanol. The eye on one side was dissected from the head, which ensures that the hairs on the inner margin of the eye are more clearly visible. Before the final slide mountings (dorsally) of the type and paratype material, the hypopygium including the IXth tergum, the anal point, the gonocoxite and the gonostylus, were viewed ventrally and laterally to examine and draw from both sides all the necessary details of the species. In particular, the ventral view of hypopygium was illustrated when anal point and tergite IX were removed. Morphological terminology and measurements largely follow Sæther (1980) and Cranston et al. (1989) for the imagines.

Results

Taxonomy

Chaetocladius castellae Moubayed-Breil, sp. n.

http://zoobank.org/A9B87258-1379-46EE-878B-B0850B31EEDF

Material examined. Holotype. **Switzerland**: Gletschboden alluvial plain, streamlet and springs located close to the upper catchment of the Rhône River, upstream to the Mutt stream confluence (station U2), altitude 1800 m, 30.IX.1998; 46°34'15.466"N, 8°22'47.054", 1 male adult, leg. B. Lods-Crozet. Environmental data of Rhône water are: crystalline water, conductivity 3.3–17.8 µS/cm; temperature 2–4 °C during late spring to late summer (June-September).

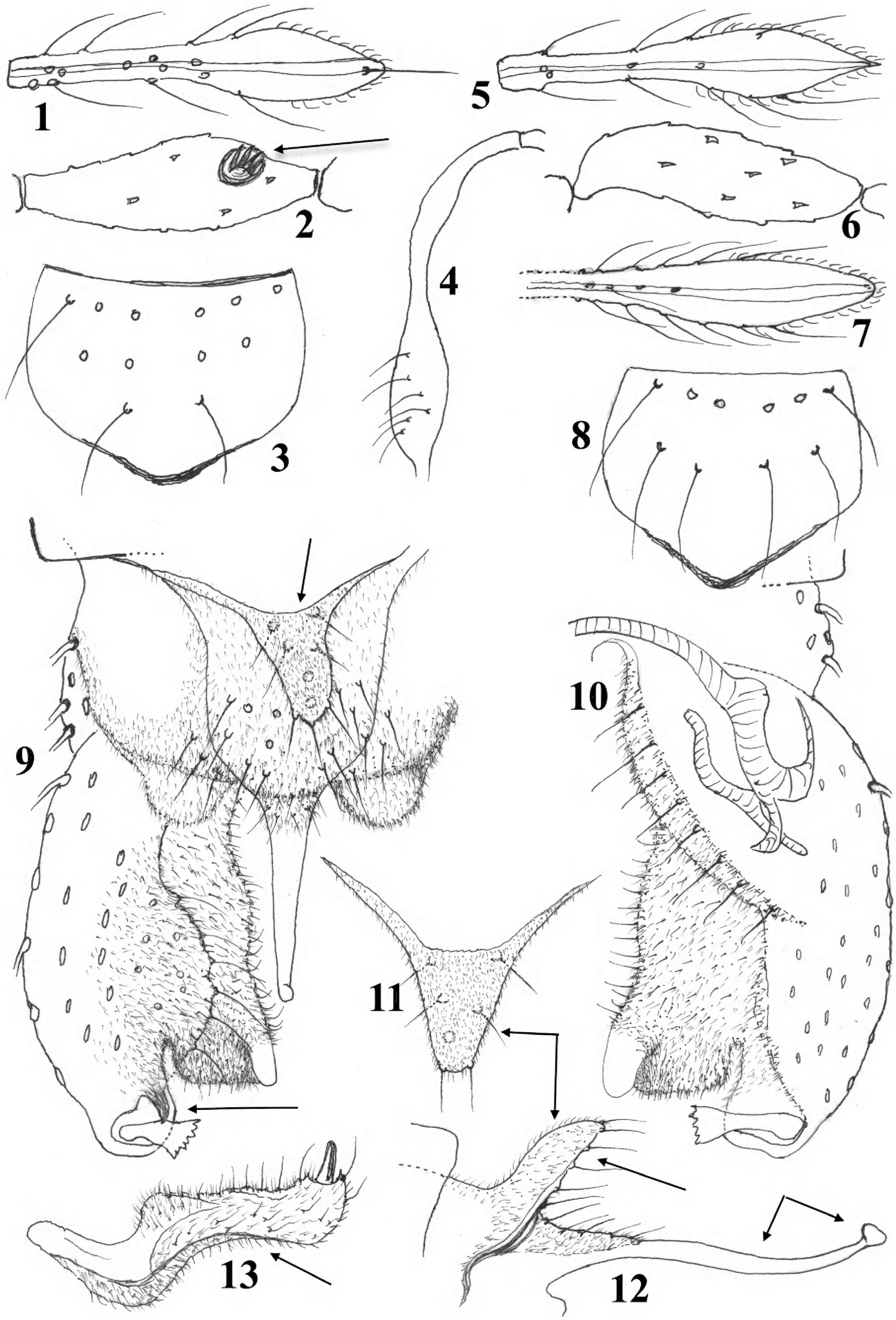
Paratypes. **Switzerland**: Mutt stream (Station M4), altitude 2100 m. 07.VIII.1997, 46°34'04.946"N, 8°24'17.159"E, 2 male adults, leg. B. Lods-Crozet. Environmental data of Mutt stream water are: crystalline water, conductivity: 61–183 µS/cm; temperature: 1–8 °C during late spring to late summer (June-September). In the streamlet and rheocrenes located close to station M4, conductivity ranged between 103 to 253 µS/cm; temperature 4.4. to 14.8 °C (Ilg et al. 2001).

Holotype (mounted on 1 slide; GBIFCH 00460692) and one paratype (on slide) are deposited in the collections of the 'Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, CH-1014 Lausanne, Switzerland. Remaining paratype (on slide) is deposited in the collection of the senior author.

Diagnosis. *C. castellae* sp. n. is separated from its nearest species (*C. insolitus* and *C. muttensis* sp. n.) by the following main characters: nearly similar shape of tergite IX, which bears a long nose-like dorsally projecting lamella-like structure; long triangular anal point; large inferior volsella; sinuous gonostylus. However, *C. castellae* sp. n. can be separated from the two previously cited species in having: palpomere 3 bearing 3–4 sensilla clavata (tubule-like) grouped in a ring; dorsal projecting lamella on tergite IX (more strongly projecting upwards), which bears 5–6 setae on ventral side; anal point long and triangular bearing 13–15 dorsal setae on its basal area and 5–6 smaller setae placed on proximal part; gonocoxite markedly swollen medially and bearing 1 row of 7–8 setae on inner dorsal margin, apex of inner dorsal margin with (or without) a distinct triangular to sub-rectangular tubercle; inferior volsella long, tongue-like, downwardly extending to distal part of gonocoxite; gonostylus nearly linear and typically sinuous.

Description. Male imago (n = 3 male adults; Figs 1–4, 9–18). Small sized *Chaetocladius* species. Total length 3.00–3.10 mm. Wing length 1.87–1.88 mm (markedly short). General colouration contrasting brown to dark brown. Head dark brown, antennae pale; thorax contrasting brown to dark brown, mesonotal stripes distinctly dark brown; wing pale; legs brown. Tergites I-VIII brown; anal segment brown to dark brown.

Head. Eyes bare, hairs present on median part of inner eye margin. Temporals consist of 10 setae including 6 inner and 4 outer verticals. Antenna 650–660 µm long, 13-segmented; length (µm) of segments: 1, 50; 2–12, 30–35 (nearly sub-equal); last flagellomere 150–160; apex of last flagellomere (Fig. 1) moderately clubbed, bearing 1 pre-apical seta and numerous sensilla chaetica; antennal groove beginning on segment 3 and reaching ultimate flagellomere; AR 0.30–0.40. Clypeus (Fig. 3) broad, nearly rectangular, cup-like in shape with rounded sides and bearing 12 setae in 3 rows. Palp 5-segmented; length (µm) of segments 1–5: 40, 45, 115, 120, 135; palpomere 3 (Fig. 2) with sensilla clavata including: 4–5 sparsely distributed and 3–4 (tubule-like) grouped in a ring which



Figures 1–13. Male adult of *Chaetocladius* spp. *C. castellae* sp. n.: **1**, last flagellomere; **2**, sensilla clavata on palpomere 3; **3**, clypeus; **4**, antepronotum, left side. *C. muttensis* sp. n.: **5**, last flagellomere; **6**, palpomere 3; **8**, clypeus. *C. insolitus*: **7**, apex of last flagellomere. Hypopygium of *C. castellae* sp. n.: **9**, dorsal; **10**, ventral with anal point and tergite IX removed; **11**, dorsal lamellae of tergite IX; **12**, anal point and tergite IX in lateral view; **13**, left gonostylus in dorsal view.

is placed on distal part. Thorax. Antepronotum (Fig. 4) well developed with fused lobes, lateral antepronotals 4–5 grouped close together; acrostichals consist of 15–16 short setae starting close to antepronotum and placed in 1–2 rows; dorsocentrals 10–11 placed in 1–2 rows; humeral pit ovoid, without contrasting spots; prealars 4–5 in 1 row; supralars absent. Scutellum with 6 uniserial setae. Wing. Brachiolum with 1 seta. Membrane densely covered with coarse punctuation. Distribution of setae on veins: R, 15–17; R_1, 2–3; R_{2+3} 12–16; remaining veins bare. Squama with 5 uniserial setae. Legs. Tibial spurs of PII and PIII are *Chaetocladius*-type, with prominent and projecting apicolateral denticles. Sensilla chaetica present on: tibia and tarsomeres ta_1-ta_2 of PI; tibia and tarsomeres ta_1-ta_3 of PII; tibia and tarsomere ta_1 of PIII. Length (µm) and proportions of legs as in Table 1.

Hypopygium in dorsal, ventral and lateral view as in Figs 9–10; ventral view (Fig. 10) with tergite IX and anal point removed. Tergite IX broadly sub-rectangular with nearly straight posterior margin; basal median area with a characteristic lamella-like structure which is orally directed and markedly visible in lateral view (Figs 9, 11, 17–18); dorsal lamella-like structure is cup-like in dorsal view and a long nose-like shape in lateral view, bearing 5–7 setae place on ventral side (dorsal side lacking setae); presence of 6–8 setae near the posterior margin (3–4 on each side of base of anal point). Anal point (Figs 9, 12, 17) about 90–95 µm long, maximum width at base 30 µm, reaching base of lobe of inferior volsella; basal part large, cup-like, bearing 13–15 dorsal setae including 5–6 smaller and placed on proximal part; median and distal part uniformly elongated and distinctly parallel-sided between base and apex, with an average of 15 µm wide; distance between base of the lamella and base of anal point 35 µm. Laterosternite IX with 5 lateral setae on each side, posterior margin distinctly bi-lobed (lobes visible on each side of the base of anal point). Transverse sternapodeme arc-like, with a distinct rounded oral projection on each side; lateral sternapodeme broad; phallapodeme slender and sinuous medially at joint with lateral sternapodeme. Virga indistinct. Gonocoxite 240–250 µm long, markedly broad medially where maximum width is about 85–90 µm; slightly truncate apically; inner dorsal margin (Fig. 9, 15, 17) markedly swollen medially and with 1 row of 7–8 curved setae, apex of inner dorsal margin bearing a characteristic conspicuous tubercle (triangular to sub-rectangular); ventral inner margin (Fig. 10) with 7–8 inwardly directed setae. Inferior volsella 160 µm long, 75 µm maximum width, clearly visible in both dorsal and ventral view; tongue-like and posteriorly extending from base of gonocoxite till its distal part; posterior margin distinctly straight, apical inner part nose-like and entirely hyaline in both dorsal and ventral sides; distal outer margin weakly separated from inner margin of gonocoxite. Gonostylus (Figs 13, 16) 140–145 µm long, maximum width 40–45 µm; nearly linear with both anterior and posterior margins markedly sinuous; crista dorsalis low and distinct, bearing several short orally directed setae; megaseta 18–20 µm long, conspicuous and slightly bent outwards.

Table 1. *Chaetocladius castellae* sp. n. Length (µm) and proportions of legs PI, PII and PIII.

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	850	940	570	320	220	140	120	0.61	2.95	3.14	2.50
PII	835	830	330	230	170	110	100	0.40	3.27	5.05	2.00
PIII	940	950	550	280	220	120	100	0.58	3.38	3.43	2.40

Taxonomic position. *C. castellae* sp. n. keys near *C. insolitus* and *C. muttensis* sp. n. based on the following resembling characters: presence of dorsal long projecting lamella-like structure; long triangular anal point; large inferior volsella; sinuous gonostylus. However, *C. castellae* sp. n. can be separated from the two previously cited species by the following main differentiating features: dorsal lamella-like structure on tergite IX is more strongly projecting and bearing setae on ventral side (Figs 9, 11, 12, 17–18), while it is entirely bare in *C. insolitus* (Caspers 1987, Figs 3–4) and *C. muttensis* sp. n. (Figs 58, 62, 65); distal part of inferior volsella differently figured in *C. muttensis* sp. n. (Figs 58–59, 65); gonostylus typically sinuous anteriorly and posteriorly (Figs 13, 16), while it is narrowing distally and bearing a typical nose-like expansion placed posteriorly in *C. muttensis* sp. n. (Figs 58, 63–65).

Etymology. The new species is named *castellae* in honour to our colleague Dr. Emmanuel Castella, who worked closely together with B. Lods-Crozet on the AASER project (AASER: Alpine and Arctic of Streams Ecosystem Research) during three years (from 1996 to 1998). He is currently senior research scientist at the University of Geneva and at the head of a research group, which focuses on aquatic invertebrate ecology.

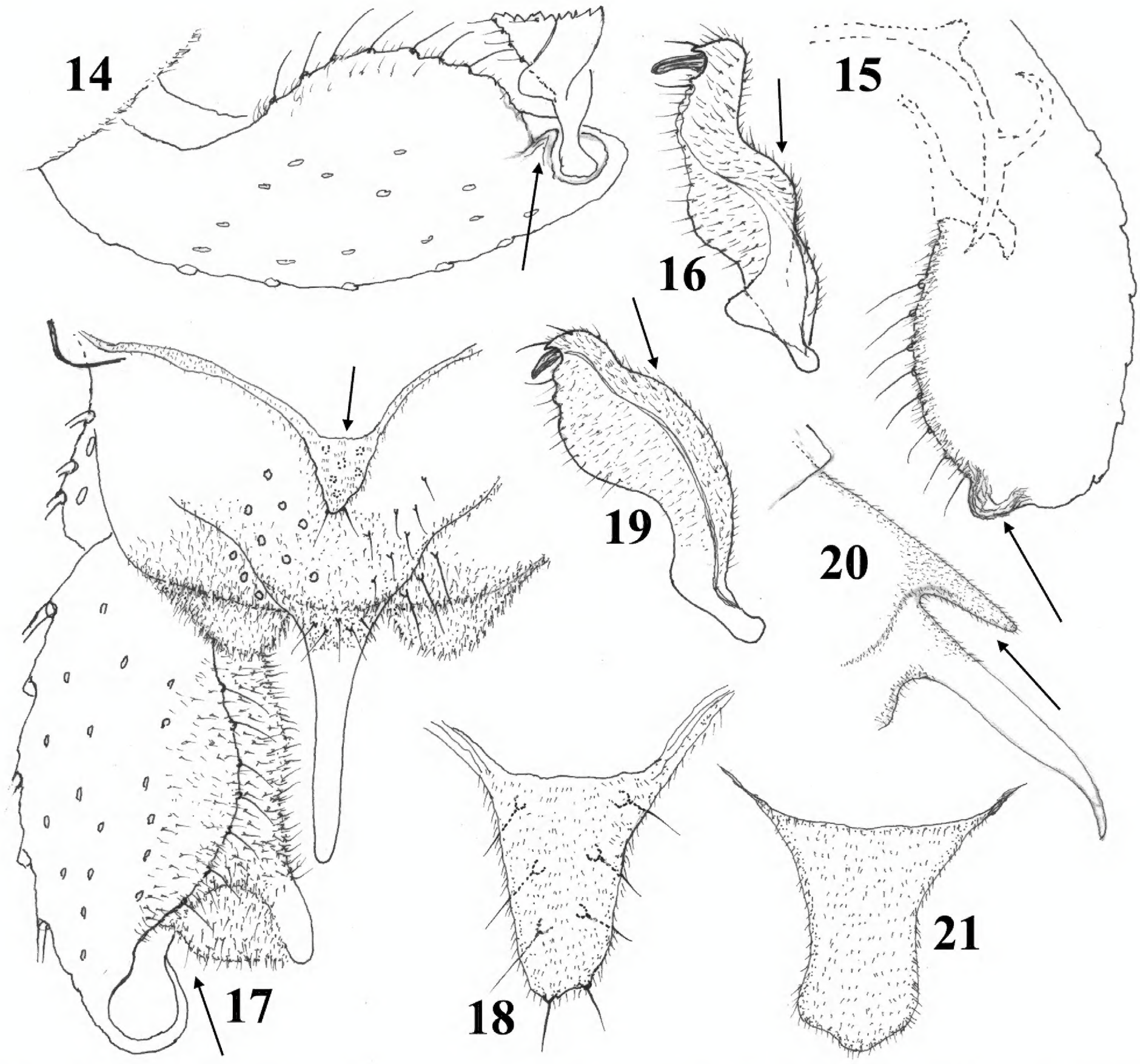
Ecology. Crenophilous species inhabiting cold mountain springs and cold streams with crystalline to calcareous water. Emergence: from July to early September.

Geographical distribution. Only known from its type locality: Central Swiss Alps.

Chaetocladius lencioniae Moubayed-Breil, sp. n.

http://zoobank.org/AD97AFCF-EC91-4DF2-9E8B-6AEEA45E560B

Material examined. Holotype. **Switzerland**: Mutt stream (station M4), altitude 2100 m, 09.VIII.1997; 46°34'04.946"N, 8°24'17.159"E, 1 male adult, leg. B. Lods-Crozet. Environmental data of Mutt stream water are: crystalline/calcareous water, conductivity 61–183 µS/cm; temperature: 1–8 °C during late spring to late summer (June-September). In the streamlet and rheocrenes located near station M4, conductivity ranged between 103 to 253 µS/cm; temperature 4.4. to 14.8 °C (Ilg et al. 2001).



Figures 14–21. Male adult of *Chaetocladius* spp. *C. castellae* sp. n. (paratype-1): **14–15**, gonocoxite, lateral and dorsal; **16**, gonostylus in dorsal view. *C. castellae* sp. n. (paratype-2): **17**, hypopygium in dorsal view; **18**, dorsal lamellae of tergite IX. *C. insolitus*: **19**, gonostylus in dorsal view; **20**, anal point and tergite IX in lateral view; **21**, dorsal lamellae of tergite IX.

Paratype. 1 male adult, same locality and data as for holotype.

Holotype (mounted on 1 slide; GBIFCH 00460691) is deposited in the collections of the 'Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, CH-1014 Lausanne, Switzerland. The single paratype is deposited in the collection of the senior author.

Diagnosis. *C. lencioniae* sp. n. keys near the following two species: *C. gracilis*, based on the shape of both tergite IX and the anal point; *C. antipovae*, based on the shape of the inferior volsella. However, *C. lencioniae* sp. n. can be distinguished in having: tergite IX semi-circular; sternite IX typically circle-like in shape; anal point markedly pointed apically and bearing setae on proximal part; virga faint, consists of 2 long teeth; gonostylus massively spherical to bulb-shaped, anterior margin swollen medially, ending in 3 characteristic small teeth comb-like placed close to the base of megaseta, posterior margin rounded, projecting downwards and terminating in a pointed sclerotized apical tooth; crista dorsalis large tooth-like, sclerotized and spherical, smooth with rounded apex, placed pre-apically close to megaseta (clearly visible in dorsal and ventral view).

Description. Male imago (n = 2 male adults; Figs 22–31). Small sized species. Total length 3.75 mm. Wing length 2.15 mm. General colouration contrasting pale brown to dark brown except for the mesonotal stripes, which are reddish dark brown. Head brownish, antennae pale brown, thorax brown with dark brown mesonotal stripes. Wing transparent. Legs brown with dark brown

tarsus. Tergites I-V brownish, tergites VI-VIII yellowish, anal segment hyaline to yellowish; gonostylus dark brown in its proximal and median part, dark brown to blackish in its distal part, megaseta and surrounding area dark brown.

Head. Eyes bare, hairs on inner eye margin absent. Temporals consist of 9–10 uniserial setae including 7–8 inner and 2 outer verticals. Antenna 1370 µm long, 12-segmented; last flagellomere (Fig. 22) 820 µm long, preceding segment 85 µm long; last flagellomere distinctly clubbed, lacking pre-apical seta and bearing a brush of curved sensilla chaetica apically; antennal groove extending from segments 3 to the ultimate flagellomere, becoming broader on last flagellomere; AR 1.50. Clypeus (Fig. 23) trapezoidal to cup-like in shape with rounded posterior margin, bearing 10 setae placed in 3 rows. Palp 5-segmented; first and second palpomeres faintly fused; length (µm) of segments: 65, 75, 205, 215, 325; 5–6 sensilla clavata are present on third palpomere. Thorax. Lateral antepronotals 3 uniserial, acrostichals 10–11 uni-biserial, dorsocentrals 14–16 uniserial, prealars 3–4 in 1 row, supraalars absent; humeral pit ovoid, nearly indistinct and lacking contrasting spots. Scutellum (Fig. 24) with 14 setae placed in 1 row along an arc line (7 on each side of the median area). Wing. Brachiolum with 1 seta. Membrane densely covered with coarse punctuation. Distribution of setae on veins: R, 13; R_1, R_{2+3}, R_{4+5} and remaining veins bare. Squama with 12 uniserial setae. Legs. Tibial spurs of PII and PIII are *Chaetocladius*-type, with prominent apicolateral denticles. Tarsomere ta_4 of PII and PIII distinctly shorter than ta_5; sensilla chaetica present only on tarsomeres ta_1-ta_3 of PI, PII and PIII (well represented on hind leg). Length (µm) and proportions of legs as in Table 2.

Hypopygium in dorsal, ventral and lateral view as in Figs 25–31; ventral view (Fig. 26) with tergite IX and anal point removed. Tergite IX semi-circular and broad with 10–11 setae placed posteriorly between base of anal point and the posterior margin (5–6 on each side). Anal point about 85–90 µm long, 65–70 µm maximum width at base, overreaching notch of inferior volsella; triangular and uniformly narrowed and sharply pointed in both dorsal (Figs 25) and lateral view (Fig. 28); base with 11–12 setae including 5–6 inserted dorsally and 6 placed on the lateral margin (3 on each side, occasionally 1 seta is inserted near the median area). Laterosternite IX typically circle-like in shape with 6–7 setae on each side. Transverse sternapodeme rounded with distinct oral projections; phallapodeme strongly broadened distally at joint with lateral sternapodeme. Virga (Figs 25, 27) faintly visible, consists of 2 long teeth about 23 µm long and fused at base. Gonocoxite 250 µm long, maximum width 95–105 µm, markedly swollen at base; inferior volsella (dorsal, Fig. 25; lateral, Fig. 31) 90–95 µm long, 30–35 µm maximum width, entirely hyaline, consists of 3 lobes; distal lobe smooth and rounded, the 2 basal lobes are strongly dented and separated by a distinct notch; posterior inner margin markedly swollen. Gonostylus (Figs 29–31) 105 µm long, maximum width 40–45 µm; massively spherical to bulb-shaped; anterior margin swollen medially, ending in 3 small characteristic pre-apical teeth, which are comb-like and pointed (clearly visible: dorsally, Fig. 29; ventrally, Fig. 30; laterally, Fig. 31); posterior margin markedly swollen distally and terminating in a pointed sclerotized apical tooth, bearing 2–3 stout orally directed setae; crista dorsalis (Figs 29–30) large tooth-like, smooth and located pre-apically close to megaseta; megaseta 20–22 µm long, 9 µm wide, conspicuous and slightly bent inwards.

Table 2. *Chaetocladius lencioniae* sp. n. Length (µm) and proportions of legs PI, PII and PIII.

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	810	1020	710	430	260	165	140	0.70	2.55	2.58	3.10
PII	840	850	390	230	150	85	100	0.46	3.68	4.33	2.75
PIII	910	1060	560	315	240	100	125	0.43	3.24	3.52	3.40

Taxonomic position. *C. lencioniae* sp. n. keys near *C. gracilis*, based on the shape of both tergite IX and the anal point (Brundin 1956, fig. 87) and *C. antipovae*, based on the shape of the inferior volsella (Makarchenko and Makarchenko, Figs 3–4). However, the new species can easily be separated from other members of the *Chaetocladius* genus in having: tergite IX semi-circular; sternite IX typically circle-like in shape; anal point markedly pointed apically and bearing setae on proximal part; virga with 2 distinct long teeth; gonostylus spherical to bulbous; anterior margin ending with 3 characteristic pointed teeth (Figs 29–31), comb-like and placed close to megaseta area (clearly visible in both dorsal, ventral and lateral view); posterior margin markedly swollen distally and terminating in a pointed sclerotized apical tooth; crista dorsalis strong tooth shaped, smooth and placed pre-apically close to megaseta.

Etymology. The new species is named *lencioniae* in honour of our colleague Dr. Valeria Lencioni from the Museum of Trento (Italy), who is active as curator 'Conservatore' and hydrobiologist in contributing to preserve the biological and ecological quality of water and environment in Trento and surrounding areas.

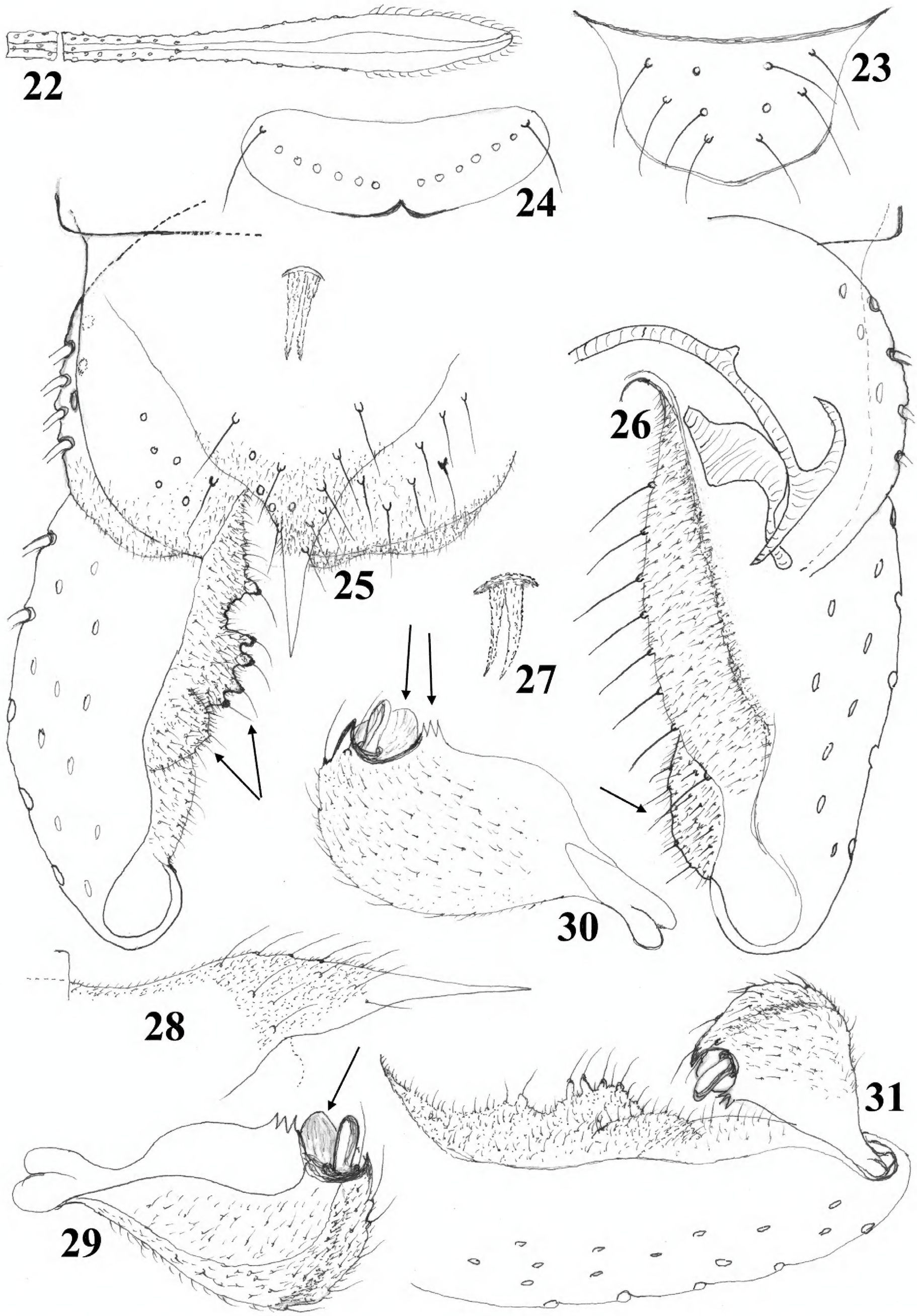
Ecology. High mountain springs and cold streams with crystalline to calcareous water. Emergence: from July to early September.

Geographical distribution. *C. lencioniae* sp. n. is only known from its type locality. It can be considered as a typical biogeographic representative of high mountain rheocrenes and cold streams delimited by some Swiss Alpine glaciers.

Chaetocladius lodscrozetae Moubayed-Breil, sp. n.

http://zoobank.org/F348A75E-E4DF-4351-B48A-2C9356133165

Material examined. Holotype. **Switzerland**: Gletschboden alluvial plain, streamlet and springs located



Figures 22–31. Male adult of *Chaetocladius lencioniae* sp. n.: **22**, last flagellomere and preceding segment; **23**, clypeus; **24**, scutellum. Hypoygium: **25–26**, dorsal (**25**) and ventral (**26**) with anal point and tergite IX removed; **27**, virga; **28**, anal point and tergite IX in lateral view; **29**, left gonostylus, dorsal; **30**, right gonostylus, ventral; **31**, gonocoxite and gonostylus in lateral view.

close to the upper catchment of the Rhône River, upstream of the Mutt stream confluence (station U2), altitude 1800 m, 08.IX.1998, 46°34'15.466"N, 8°22'47.054", 1 male adult, leg. B. Lods-Crozet. Environmental data of Rhône water are: crystalline water, conductivity 3.3–17.8 µS/cm; temperature 2–4 °C during late spring to late summer (June-September).

Paratypes (all leg. B. Lods-Crozet). **Switzerland.** 1 male adult, same locality and data as for holotype. 2 male adults, Gletschboden, upstream, altitude 1800 m, 30.IX.1999. 1 male adult, Mutt stream (station M4), altitude 2100 m, 07.VIII.1997, Swiss coordinates: 2'674'059, 1'157'904. Environmental data of Mutt stream water are: crystalline/calcareous water; conductivity: 61–183 µS/cm; temperature: 1–8 °C during late spring to late summer (June-September). In the streamlet and rheocrenes located near the station M4, conductivity ranged between 103 to 253 µS/cm; temperature 4.4. to 14.8 °C (Ilg et al. 2001).

Holotype (mounted on 1 slide; GBIFCH 00460693) and 1 male paratype (on 1 slide; GBIFCH 00460694) are deposited in the collections of the 'Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, CH-1014 Lausanne, Switzerland. Remaining paratypes are deposited in the collection of the senior author.

Diagnosis. The nearest species to *C. lodscrozetae* sp. n. are *C. dissipatus*, *C. holmgreni*, *C. egorych* and *C. aedeagolobatus* Rossaro, Magoga & Montagna, 2017 from which it can be separated in having: clypeus half diamond-like, with V-shaped posterior side, bearing 6 setae placed in 2 rows; palpomere 4 distinctly truncate apically, sensilla clavata present on segment 3 including 5 sparsely distributed and 3 (tubule-like) grouped on a ring placed distally; ultimate flagellomere 465–475 µm long, distinctly clubbed, AR about 1; tergite IX broad and semi-circular with 16–22 dorsal setae placed on its posterior part; anal point long, triangle-like, nearly parallel-sided and distinctly thin between base and apex, dorsally bearing a characteristic massive lamella-like orally directed structure which is markedly visible in lateral view, lamella is cup-like in dorsal view, composed of 2 well separate margins, inner margin linear and bare, outer margin markedly undulated and bearing 7–8 dorsolateral setae, inside area bare; virga typical inversed V-shaped, composed of 6–7 posteriorly directed spines; gonocoxite broad basally and narrowed distally, abruptly tapering before apex; inferior volsella extending from base of gonocoxite to its distal part, consist of 2 lobes (dorsal lobe markedly projecting medially and beak-like in shape, distal part distinctly swollen and pouch-like in shape; ventral lobe swollen basally and tapering distally, ending nearly at tip of gonocoxite, inner ventral margin bearing about 11 strong setae; gonostylus half bulb-shaped ending with a distinct hyaline rounded distal area, anterior side with orally directed small setae, posterior margin markedly rounded bearing a double inner apical margin, anterior margin varies from straight to convex, crista dorsalis low and indistinct.

Description. Male imago (n = 4 male adults; Figs 32–44). Medium sized species. Total length 3.80–3.90 mm. Wing length 2.00–2.13 mm. General colouration contrasting brown to dark brown. Head dark brown, antennae pale brown, thorax brown to dark brown, mesonotal stripes distinctly dark brown; wing pale; legs contrasting brown to dark brown. Tergites I-VI/VII brown, tergites VII-VIII and anal segment entirely dark brown.

Head. Eyes bare, hairs present anterior part of inner eye margin. Temporals consist of 11–12 setae including 7–8 uniserial inner and 4 outer verticals. Antenna 915–920 µm long, 13-segmented; ultimate flagellomere 465–475 µm long, distinctly clubbed distally and bearing a dense brush of curved sensilla chaetica apically, apex (Fig. 34) lacking pre-apical setae; antennal groove beginning on segments 3–4 and reaching ultimate flagellomere; AR 1.02. Clypeus (Fig. 35) about 105 µm maximum height and 120 maximum width, half diamond-like, with V-shaped posterior side, which is rounded apically, bearing 6 setae placed in 2 rows: 4 near the basal margin, 2 on median part. Palp 5-segmented, first and second palpomeres fused; palpomere 4 distinctly truncate apically; length (µm) of segments: 38, 75, 150, 130, 175–180; palpomere 3 (Figs 32–33) with sensilla clavata including 5 sparsely distributed and 3 grouped on a characteristic ring placed distally. Thorax. Antepronotum well developed, with fused lobes. Lateral antepronotals 5 grouped close together apically; acrostichals 10–11 uniserial; dorsocentrals 8–9 in 1 row, prealars 3; humeral pit ovoid, lacking contrasting spots. Scutellum with 8 setae in 1 row (4 placed on each side of median area). Wing. Brachiolum with 1 seta. Membrane densely covered with coarse punctuation. Distribution of setae on veins: R, 10–11; R_1, 0–1; remaining veins bare. Squama with 5–10 uniserial setae. Legs. Tibial spurs of PII and PIII are *Chaetocladius*-type, with projecting apicolateral denticles. Sensilla chaetica present on: tibia and tarsomere ta_1 of PI and PII; tarsomeres ta_1-ta_3 of PIII. Length (µm) and proportions of legs as in Table 3.

Hypopygium in dorsal, ventral and lateral view as in Figs 36–44; ventral view (Fig. 37) with tergite IX and anal point removed. Tergite IX broad and semi-circular with 16–22 dorsal setae placed on the posterior part (7–8 setae on each side of base of anal point); presence of a characteristic massive rounded prominence extending from the median area to base of anal point; prominence is cup-like in shape in dorsal view (Fig. 36) and orally directed in lateral view (Fig. 40), outer margin is markedly undulated and bearing 8–10 dorsolateral setae (4–5 placed on each side), inside area bare. Anal point (Figs 36, 40) about 80–85 µm long, maximum width 40–45 µm at base, markedly elongated and reaching inner lobe of inferior volsella; in dorsal view (Fig. 36), median and distal part linear to parallel-sided with an average of 3–5 µm wide; in lateral view (Fig. 40), distinctly thicker on proximal half, becoming thinner on its distal half, often bent downwards, apex slightly curved upwards. Laterosternite IX with 5 setae on each side. Transverse sternapodeme arc-like, with distinct

Table 3. *Chaetocladius lodscrozetae* sp. n. Length (µm) and proportions of legs PI, PII and PIII.

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	790	885	560	320	240	150	110	3.63	2.73	2.99	2.20
PII	820	830	370	230	180	110	100	3.45	3.26	4.46	2.90
PIII	890	980	585	325	260	145	110	3.60	3.43	3.20	2.30

rounded oral projections; lateral sternapodeme slender and distinctly short; phallapodeme sinuous medially at joint with lateral sternapodeme. Virga (Fig. 38) inversed V-shaped, composed of 6–7 posteriorly to laterally directed spines. Gonocoxite 280–285 µm long, markedly broad basally, maximum width 85–90 µm, narrowed and abruptly tapering distally, apex rounded and bearing 4–5 apical setae; inner ventral margin with about 11 strong setae; apical margin with 2–3 stout setae. Inferior volsella 120 µm long, maximum width 45 µm, extending from base of gonocoxite to its distal part (about 65 µm distance from apex of gonocoxite); similarly shaped in both dorsal, ventral and lateral view (Figs 36–37, 39, 41); median inner margin terminating in a nose-like lobe which is hyaline, bare and bent downwards; distal part pouch-like in shape. Gonostylus (Figs 41–44) 100–110 µm long, 40–45 µm maximum width, nearly semi-circular, distal part of posterior margin bare and hyaline; anterior side smooth in general, varies from straight (Figs 42–43) to convex (Fig. 44), bearing numerous orally directed small setae; crista dorsalis low and indistinct; megaseta 18–20 µm long, conspicuous, occasionally with pointed apex, slightly bent inwards.

Taxonomic position. *C. lodscrozetae* sp. n. keys close to *C. dissipatus*, *C. holmgreni*, *C. egorych* and *C. aedeagolobatus* from which it can be separated in having: sensilla clavata present on palpomere 3 including 5 sparsely distributed and 3 grouped on a characteristic ring placed distally; tergite IX broad and nearly semi-circular with 10–11 setae on its posterior area, presence of a characteristic massive rounded prominence extending from the median area to base of anal point; anal point elongated and parallel-sided which is distinctly thicker on its proximal half; virga inversed V-shaped, composed of 6–7 posteriorly directed spines; gonocoxite broad basally and narrowed distally, abruptly tapering before apex; inferior volsella extending from base of gonocoxite to its distal part, consist of a large lobe which is pouch-like in shape, inner margin terminating in a hyaline nose-like lobe which is bare and bent downwards; gonostylus nearly semi-circular, distal part of posterior margin hyaline and bare, anterior side with orally directed small setae, anterior margin varies from straight to convex.

Etymology. The new species is named *lodscrozetae* in honour of Dr. Brigitte Lods-Crozet from the Cantonal Museum of Zoology of Lausanne (Switzerland), who is still active as researcher and hydrobiologist in contributing to preserve the biological and ecological quality of water and environment in Switzerland.

Ecology. Glacial springs and cold mountain streams with crystalline to calcareous water. Emergence: from July to early September.

Geographical distribution. *C. lodscrozetae* sp. n. is only known from rheocrenes and lotic habitats delimited by the Gletschboden floodplain, the Mutt stream and streamlet, Swiss Alps, altitude 1800–2100 m.

Chaetocladius macunensis Moubayed-Breil, sp. n.

http://zoobank.org/75DA3760-22C8-4357-8DF7-ABD7E9F98E42

Material examined. Holotype. **Switzerland**: Macun cirque, streamlet and rheocrenes, left shore of Immez Lake, alt. 2616 m, 27.VII.2013; 46°43'39.678", 10°07'55.764"E, 1 male adult, leg. B. Lods-Crozet. Environmental data from inlet of Immez Lake: crystalline water, conductivity 5.9 µS/cm; temperature 11.6 °C, pH 6.7 (Robinson and Oertli 2009).

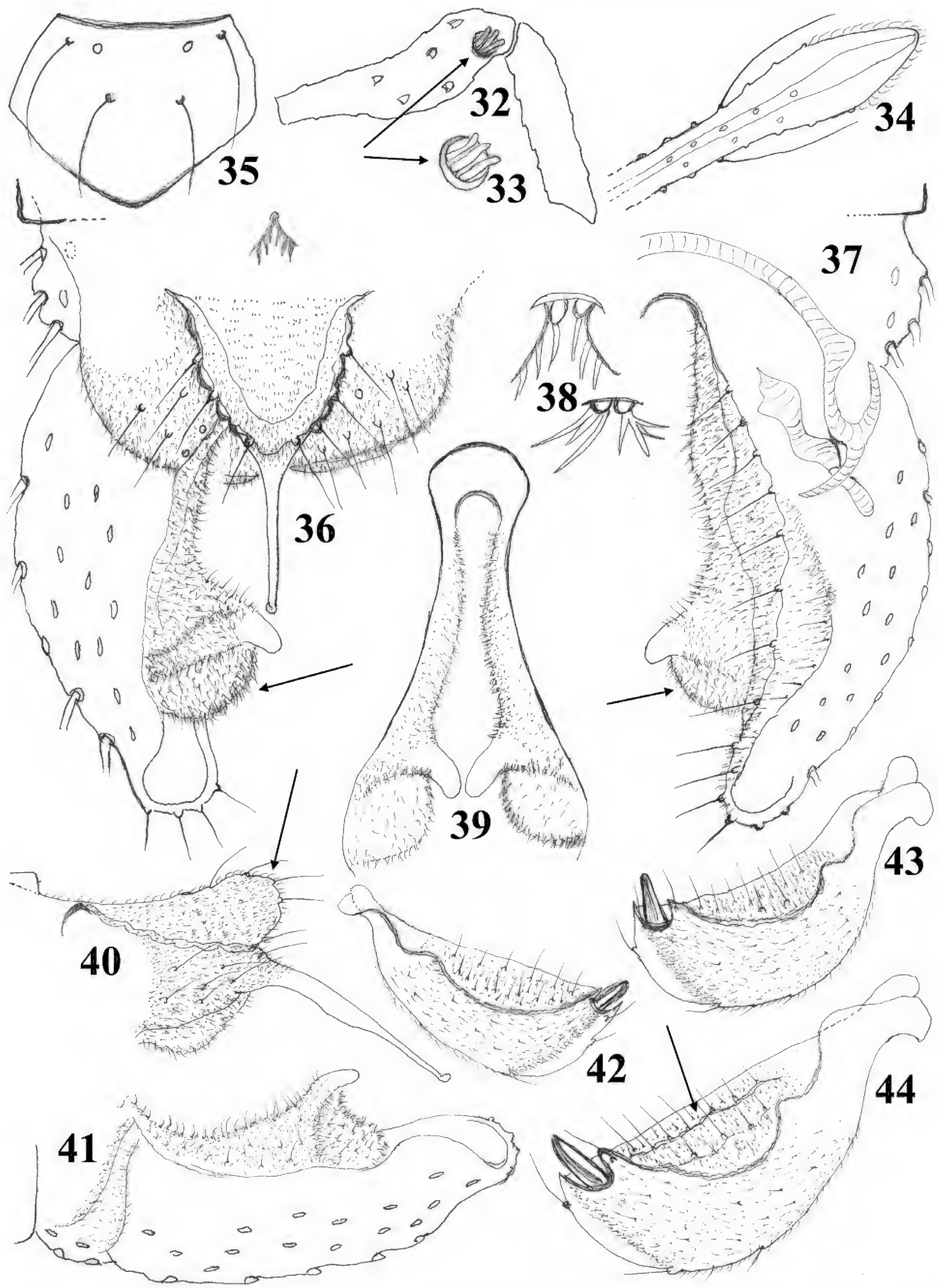
Paratypes. 3 male adults, same locality and data as for holotype.

Holotype (mounted on 1 slide; GBIFCH 00460690) is deposited in the collections of the 'Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, CH-1014 Lausanne, Switzerland. Paratypes are deposited in the collection of the senior author.

Diagnosis. Based on the unusual and unique shape of the inferior volsella, *C. macunensis* sp. n. can be easily separated from other members of the *Chaetocladius* genus by the following characters: clypeus semi-circular bearing 7 setae placed in 1 row along an arc line; antenna and ultimate flagellomere relatively short (respectively 600–660 and 130–200 µm long), apex distinctly clubbed and bearing 1 pre-apical seta, AR markedly low (0.25–0.35); tergite IX sub-triangular and lacking dorsal setae; anal point triangular, uniformly narrowed, apex rounded, base with 6 setae inserted dorsolaterally (3 on each side); virga horseshoe-shaped, median tooth sinuous and S-like in shape; gonocoxite markedly swollen medially and distally, inner dorsal margin without stout setae, inner ventral margin swollen medially; inferior volsella consists of 1 single large and typical lobe, which bears numerous strong stout setae on its inner margin; gonostylus elongated and nearly linear, anterior side covered with setae, posterior margin nearly straight.

Description. Male imago (n = 2 male adults; Figs 45–57). *C. macunensis* sp. n. is one of the smallest species of *Chaetocladius*. Total length 3.55–3.65 mm. Wing length 1.35 mm. General colouration contrasting brown to dark brown. Head yellowish to brown; antennae and pedicel dark brown; thorax contrasting brown to dark brown, mesonotal stripes distinctly dark brown; wing transparent; legs brownish with tarsomeres ta_5 dark brown. Abdomen including anal segment entirely brownish.

Head, thorax and tergite I as in Fig. 45. Eyes mostly bare, extreme posterior part with few hairs; inner mar-



Figures 32–44. Male adult of *Chaetocladius lodscrozetae* sp. n.: **32–33**, palpomeres 3–4 with sensilla clavata on palpomere 3; **34**, last flagellomere; **35**, clypeus; **36–37**, hypopygium, dorsal (**36**) and ventral (**37**) with anal point and tergite IX removed; **38**, virga, two aspects; **39**, ventral view of inferior volsella; **40**, anal point and tergite IX in lateral view; **41**, left gonocoxite in lateral view; **42–44**, gonostylus, lateral (**42**), dorsal (**43**) and dorso-lateral (**44**).

gin bare. Temporals consist of 4 uniserial setae comprising only inner verticals, outer verticals absent. Antenna 730–800 µm long, 13-segmented; ultimate flagellomere (Fig. 46) 130–200 µm long, relatively short; apex of last flagellomere distinctly clubbed, bearing 1 pre-apical seta and curved sensilla chaetica; segments 11 and 12 each about 20 µm long; antennal groove beginning on segments 3 and reaching ultimate flagellomere; antennal ratio markedly low, AR 0.25–0.35. Clypeus (Fig. 48) 125 µm maximum width and 75 µm high, nearly rectangular with rounded sides, bearing 7 setae placed anteriorly in 1 row along an arc line. Palp 5-segmented; first and second palpomeres nearly fused; length (µm) of segments: 15, 55, 105, 115, 160; palpomere 4 distinctly broadened (37 µm maximum width); palpomere 3 (Fig. 47) with 4–5 sensilla clavata. Thorax. Antepronotum (Fig. 49) well developed with gaping lobes, lateral antepronotals 4–5; acrostichals 12–13, short and starting close to the antepronotum; dorsocentrals, 15–16 in 1 row; prealars 4–5; humeral pit ovoid, indistinct. Scutellum with 7 uniserial setae placed along an inversed arc-like (1 medially and 3 on each side of it). Wing. Brachiolum with 1 seta. Membrane densely covered with coarse punctuation. Distribution of setae on veins: R 11; R1 3; R2+3 6–7 placed distally; R4+5 0. Squama composed of 38–41 alternate long and short setae placed in 1 row. Legs. Tibial spurs of PII and PIII are *Chaetocladius*-type, with prominent apicolateral denticles. Sensilla chaetica (Fig. 50) present on tarsomeres ta_1-ta_4 of PI, PII and PIII. Length (µm) and proportions of legs as in Table 4.

Hypopygium in dorsal, ventral and lateral view as in Figs 52–57; ventral view (Fig. 53) with tergite IX and anal point removed. Tergite IX broadly triangular and narrowed posteriorly till base of anal point, lacking dorsal setae. Anal point (Figs 51–52, 57) about 60–65 µm long, 15-20 µm maximum width at base, reaching half of inferior volsella length; triangular, uniformly narrowed towards apex which is slightly pointed; base markedly truncate bearing an obtuse prominence which is only visible in lateral view (Fig. 51, 57), presence of 6 setae inserted dorsolaterally (3 on each side). Laterosternite IX with 5 setae on each side, posterior margin with 1 lobe placed near the base of anal point. Transverse sternapodeme rounded with distinct oral projections placed laterally, lateral sternapodeme distinctly short; inner margin of phallapodeme with a median triangular projection, outer margin weakly swollen at joint with lateral sternapodeme. Virga (Fig. 52, 54) distinctly horseshoe-shaped, 15–17µm maximum width; base sub-circular, 15 µm maximum width; median tooth about 20–22 µm long, sinuous and S-like in shape. Gonocoxite 210–215 µm long, maximum width 80–85 µm; in dorsal view (Fig. 52) markedly swollen medially and distally, inner dorsal margin lacking strong stout setae; in ventral view (Fig. 53), the inner margin is swollen medially and bearing 7 stout setae; inferior volsella (Fig. 52, 57) 60–65 µm long, 15–18 µm maximum width, consists of 1 single large lobe, swollen medially and slightly narrowed distally (distinctly visible in dorsal and lateral view, Figs 52, 57),

Table 4. *Chaetocladius macunensis* sp. n. Length (µm) and proportions of legs PI, PII and PIII.

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	550	650	410	290	210	120	100	0.63	2.24	2.93	2.40
PII	675	655	290	160	140	91	82	0.44	3.42	3.24	2.10
PIII	725	775	420	220	190	120	98	0.54	3.06	3.57	2.30

with numerous setae placed on its inner margin. Gonostylus (Figs 55–57) 105–110 µm long, maximum width 25 µm; uniformly elongated, anterior side covered with small setae; posterior margin nearly straight, ending with distinct tooth; crista dorsalis low to nearly absent; megaseta 21–23 µm long, conspicuous and slightly bent inwards.

Taxonomic position. *C. macunensis* sp. n. can be easily separated from its nearest species (*C. tenuistylus*, sensu Makarchenko and Makarchenko 2004, Fig. 10) by the following main distinguishing characters: ultimate flagellomere relatively short (130–200 µm long), apex clubbed and bearing 1 pre-apical seta (Fig. 5), antennal ratio markedly low (0.25–0.35); tergite IX sub-triangular and lacking dorsal setae; anal point triangular with a truncate prominence (obtuse angle) placed near the base which is only visible in lateral view (Figs 51, 57); virga typically horseshoe-shaped, base circular with its 2 apices distinctly curved inwards, median tooth S-like in shape; anal point triangular and tapering distally; inferior volsella consists of a large lobe which is typically swollen medially and slightly narrowed distally; gonostylus elongated and nearly linear, anterior side covered with setae, posterior margin nearly straight.

Etymology. The new species is named *macunensis* after the Swiss Alpine cirque of Macun, which was annexed to the Swiss National Park in 2000 (canton of Graubunden).

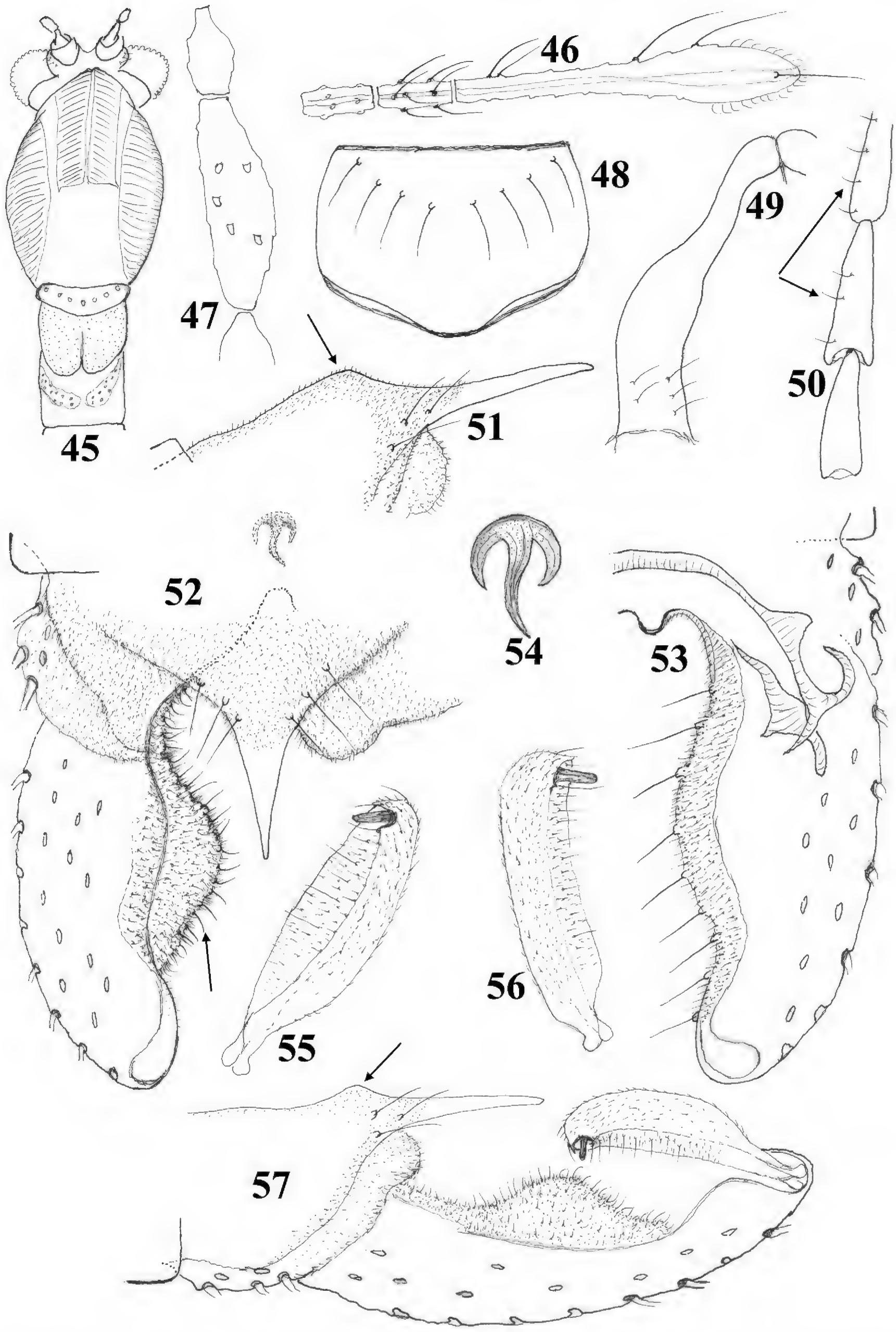
Ecology. *C. macunensis* sp. n. is apparently confined to cold glacial streams and the inflow section of lakes delimited by the Macun cirque where water is typically crystalline. Emergence is recorded from July to early September.

Geographical distribution. A typical biogeographic representative of Alpine high mountain springs and glacial streams located in the eastern Swiss Alps area. Currently, *C. macunensis* sp. n. is only known from the Macun cirque.

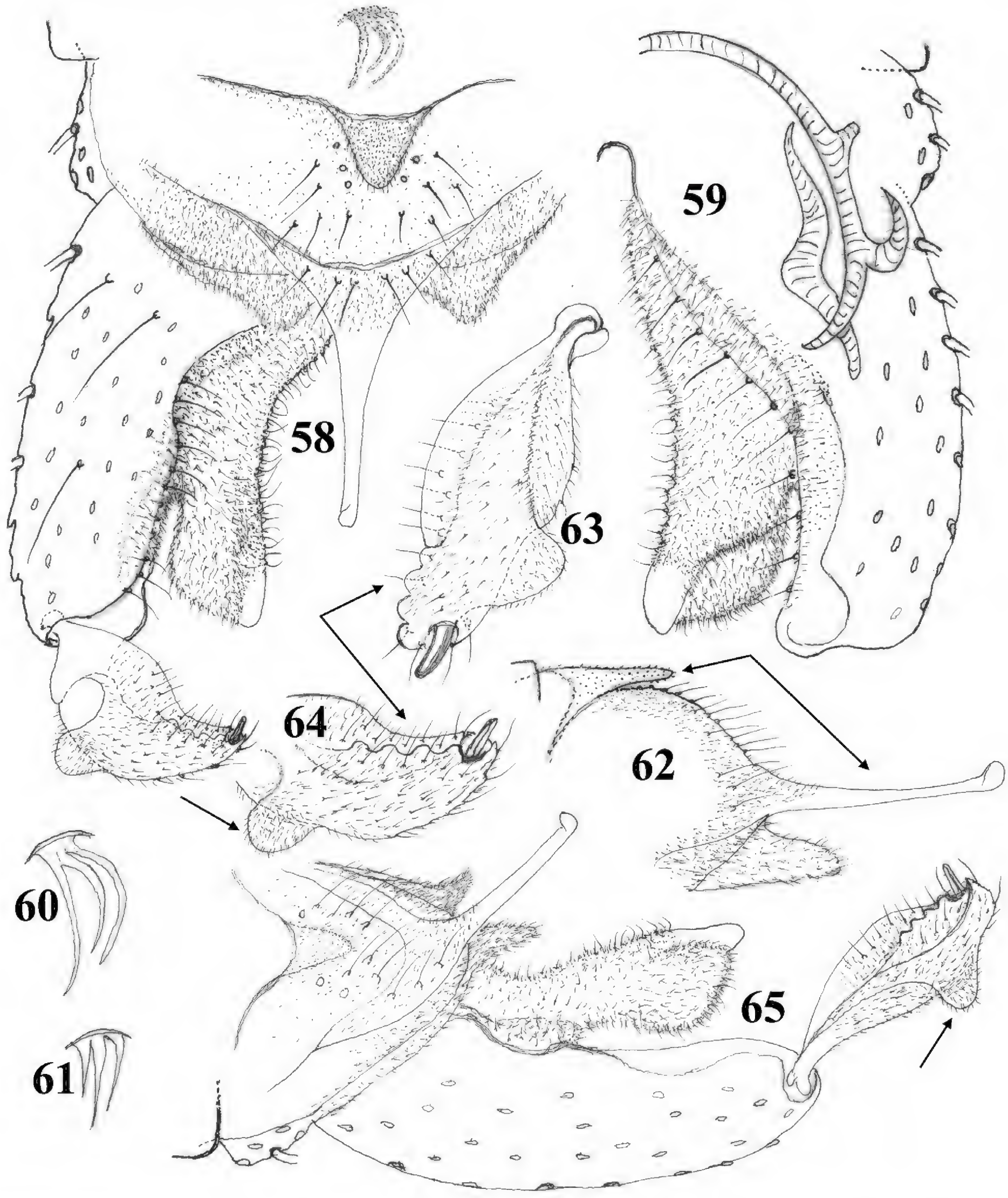
Chaetocladius muttensis Moubayed-Breil, sp. n.

http://zoobank.org/13D2E7A8-EFB6-47F0-85C7-3BD46B5F3DB7

Material examined. Holotype. **Switzerland**: upper basin of the Mutt glacial stream (station M5), altitude 1800 m, 03.VIII.1997, 46°34'12.347"N, 8°22'51.363", 1 male adult, leg. B. Lods-Crozet. Environmental data of Mutt stream water are: crystalline to calcareous water, conductivity 61–183 µS/cm; temperature: 1–8 °C during late spring to late summer (June-September).



Figures 45–57. Male adult of *Chaetocladius macunensis* sp. n.: **45**, palpomeres 2–3; **46**, last flagellomere and the two preceding segments; **47**, clypeus; **48**, head, thorax and first abdominal segment; **49**, antepronotum, left side; **50**, tarsomeres 2–4 of PIII; **51**, anal point and tergite IX in lateral view; **52–53**, hypopygium, dorsal (**52**) and ventral with anal point and tergite IX removed (**53**); **54**, virga; **55**, left gonostylus, dorsal; **56**, right gonostylus, lateral; **57**, anal point, gonocoxite and gonostylus in lateral view.



Figures 58–65. Male adult of *Chaetocladius muttensis* sp. n. **58–59**, hypopygium, dorsal (**58**) and ventral with anal point and tergite IX removed (**59**); **60–61**, virga, two aspects; **62**, tergite IX and anal point in lateral view; **63**, right gonostylus, lateral; **64**, left gonostylus, distal part (dorsal); **65**, anal point, gonocoxite, tergite IX and gonostylus in lateral view.

Paratype. **Switzerland**: upper basin of Mutt stream (station M4), altitude 2100 m, 09.VIII.1997, 46°34'04.946"N, 8°24'17.159"E, 1 male adult, leg. B. Lods-Crozet. Environmental data of Mutt stream water are: crystalline to calcareous water, conductivity 61–183 µS/cm; temperature: 1–8 °C during late spring to late summer (June-September). In the streamlet and springs located close to station M4, conductivity ranged between 103 to 253 µS/cm; temperature 4.4 to 14.8 °C (Ilg et al. 2001).

Holotype (mounted on 1 slide; GBIFCH 00460695) is deposited in the collections of the 'Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, CH-1014 Lausanne, Switzerland. The single paratype is deposited in the collection of the senior author.

Figure 66. The Mutt stream valley with the Mutt glacier in the back and in the foreground station M4 (Photo, B. Lods-Crozet).

Diagnosis. *C. muttensis* sp. n. can be separated from its nearest species (*C. insolitus* and *C. castellae* sp. n.) by the following characters: tergite IX bearing a characteristic dorsal lamella-structure which is bare and slightly projecting close to the dorsal side of tergite IX; anal point triangular, widely broad at base and bearing 6 setae at base

Figure 67. Cirque of Macun, Eastern Alps, Swiss National Park, altitude 2616–2700 m (photo © *hepia*).

(3 on each side); virga faint but present, consists of 3 long spines; inferior volsella tongue-like with distal outer margin well separated from inner margin of gonocoxite; inner margin of gonocoxite not swollen medially and lacking row of strong setae; gonostylus gradually narrowing distally, anterior area with a characteristic undulate line placed distally and reaching base of megaseta, posterior margin with a typical lob-like expansion placed medially and directed downwards.

Description. Male imago (n = 2 male adults; Figs 5, 6, 8, 58–65). A medium sized species, total length 2.90–3.00 mm. Wing length 1.60–1.75 mm (markedly short). General colouration faintly contrasting brown to dark brown. Head including palpomeres, clypeus and antennae brown to pale brown; thorax brown to dark brown, mesonotal stripes distinctly dark brown; wing pale; legs brown to dark brown. Tergites I-VIII and anal segment brown to dark brown.

Head. Eyes bare, hairs absent on median part of inner eye margin. Temporals consist of 8 setae including 5 inner and 3 outer verticals. Antenna 575–585 µm long, 13-segmented; last flagellomere (Fig. 5) 135–145 µm long, well clubbed, pointed apically, bearing numerous sensilla chaetica apically and lacking pre-apical seta; antennal groove beginning on segment 3 and reaching ultimate flagellomere; AR 0.30–0.35. Clypeus (Fig. 8) trapezoidal with straight sides, bearing 8–10 setae in 2 rows. Palp 5-segmented; length (µm) of segments 1–5: 30, 35, 105, 125, 180; palpomere 3 (Fig. 6) with 4–5 sparsely distributed sensilla clavata. Thorax. Lateral antepronotals 4–5; acrostichals 8–9, short and starting close to antepronotum; dorsocentrals 12–13 in 1–2 rows; prealars 4–5; humeral pit ovoid, lacking contrasting spots. Scutellum with 8 setae placed in 1 row. Wing. Brachiolum with 1 seta. Membrane densely covered with coarse punctuation. Distribution of setae on veins: R, 14–15; R_1, 1–2; R_{2+3} 12–13; remaining veins bare. Squama with 5–6 uniserial setae. Legs. Tibial spurs of PII and PIII are *Chaetocladius*-type, with projecting apicolateral denticles. Sensilla chaetica present on: tibia and tarsomeres ta_1- ta_4 of PI; tibia and tarsomres ta_1-ta_3 of PII; tarsomres ta_1- ta_4 of PIII. Length (µm) and proportions of legs as in Table 5.

Hypopygium in dorsal, ventral and lateral view as in Figs 58–65; ventral view (Fig. 59) with tergite IX and anal point removed. Tergite IX broad, sub-rectangular with nearly semi-circular to straight posterior margin; basal median area with a characteristic lamella-like structure which is weakly projecting and markedly vis-

Figure 68. Malaise trap set up at Immez Lake (Macun cirque, Eastern Alps, Swiss National Park, altitude 2616 m (photo J.L. Lods).

Table 5. *Chaetocladius muttensis* sp. n. Length (µm) and proportions of legs PI, PII and PIII.

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	840	895	550	310	205	120	100	0.62	3.11	3.15	1.50
PII	815	790	370	215	160	105	95	0.47	3.45	4.34	2.20
PIII	890	925	520	290	210	115	95	0.56	3.29	3.49	3.25

ible in lateral view (Fig. 62); dorsal lamella-like projection 45–50 µm long, maximum width 55–60 µm at base, wide cup-like in dorsal view (Figs 58, 65) and long finger-like shape in lateral view (Fig. 62), bare in both dorsal and lateral sides; presence of 14–15 setae placed medially and near the posterior margin. Anal point (Figs 58, 62, 65) about 80–90 µm long, maximum width at base 16–18 µm, uniformly elongated and reaching distal part of inferior volsella; horizontally straight (Figs 58, 62) or occasionally projecting upwards (Fig. 65); basal part wide cup-like bearing 6 setae (3 on each side); parallel-sided medially and distinctly narrowing between median part and apex. Laterosternite IX with 5 lateral setae on each side, posterior margin distinctly bi-lobed (lobes visible on each side of the base of anal point). Transverse sternapodeme arc-like, with distinct tubercle-like oral projections; lateral sternapodeme relatively short; phallapodeme projecting inwards medially. Virga (Figs 59, 60–61) faintly present, consist of 3 long curved spines. Gonocoxite about 250 µm long, broad medially where maximum width is about 80 µm; apex of inner margin distinctly rounded and projecting inwards; ventral side (Fig. 59) wider at base and narrowed distally, inner margin with 10–11 inwardly directed setae. Inferior volsella about 110–115 µm long, 55–60 µm maximum width; long rectangle-shaped and extending from base of gonocoxite to its distal part which is markedly truncate; distal part tongue-like, well separated from the inner margin of gonocoxite (separating part is well visible in both dorsal and ventral view, Figs 58–59); posterior margin bent inwards; apical inner part nose-like, bare and entirely hyaline in both dorsal and ventral sides. Gonostylus (Figs 58, 63–65) 120–125 µm long, maximum width 40–45 µm; narrowing distally, anterior area with a characteristic undulate line extended from median part to base of megaseta, posterior margin rounded and bearing a typical lobe-like expansion which is placed medially and directed downwards; crista dorsalis weekly developed, swollen proximally and becoming gradually lower distally; megaseta 15–18 µm long, conspicuous and slightly bent outwards.

Taxonomic position. *C. muttensis* sp. n. keys near *C. insolitus* and *C. castellae* sp. n. from which it can be separated in having: tergite IX with a characteristic dorsal cup-like lamella-structure, bare and slightly projecting (Fig. 62); anal point widely broad at base which bears about 6 setae; virga faint but present, consists of 3 long

curved spines; inferior volsella tongue-like with distal outer margin well separated from inner margin of gonocoxite; inner margin of gonocoxite not swollen medially and lacking row of strong setae; gonostylus (Figs 58, 63–65) gradually narrowing, anterior area with a characteristic undulate line, posterior margin with a typical lobe-like expansion placed medially and directed downwards.

Etymology. The new species is named *muttensis* after the Swiss Alpine glacial Mutt stream, which is located in the upper basin of the Rhône River in the central Swiss Alps.

Ecology. *C. muttensis* sp. n. only occurs in the Mutt glacial stream where larvae are apparently confined to the lotic part of springs and the rhithral (crystalline to calcareous water). Emergence from July to early August. Associated species found in the same locality include: *C. laminatus* Brundin, 1947; *C.* cf. *longivirgatus* Stur & Spies, 2011; *C. suecicus* (Kieffer, 1916); *Heleniella helvetica.*

Geographical distribution. *C. muttensis* sp. n. is only known from its type locality, which is delimited by the upper basin of the Mutt glacial stream.

Key to known adult males of *Chaetocladius* species from the upper catchment of Rhône River including Muttbach valley (Central Swiss Alps)

1 Tergite IX with a dorsal lamella structure located on median area (Figs 9, 17, 58) 2
– Tergite IX without such dorsal lamella structure 3
2 Gonostylus gradually narrowing distally, anterior area with a typical undulate line extended from median part to base of megaseta, posterior margin rounded and bearing a characteristic lobe-like expansion directed downwards (Figs 58, 63–65); lamella structure on tergite IX without setae (Fig. 58)..... *C. muttensis* sp. n.
– Gonostylus linearly elongated, both anterior and posterior margin sinuous (Figs 13, 16); anterior area without undulate line; lamella structure on tergite IX with stout setae on ventral side and posterior margin (Figs 11–12, 18) ..... *C. castellae* sp. n.
3 Gonostylus bulbous and spherical (Figs 29–31) 4
– Gonostylus not as above, slender, semi-circular with rounded posterior margin (Figs 42–44) or linear and uniformly elongated with straight posterior margin (Figs 55–57) 5
4 Inferior volsella (Figs 25, 31) weekly developed, consists of 3 lobes, basal lobe smooth and rounded, the 2 basal lobes are markedly dented and separated by a distinct notch; posterior margin of gonostylus bearing 3 small pre-apical teeth; crista dorsalis large tooth shaped, smooth with rounded apex and placed pre-apically close to megaseta (Figs 29–30).... ..... *C. lencioniae* sp. n.
5 Tergite IX bearing a dorsal elevated massive hump, located distally (Figs 36, 40) which is spherical and clearly visible in lateral view (Fig. 40); basal margin of anal point undulated (Fig. 36) and bearing setae; inferior volsella composed of a large spherical lobe bearing medially a nose-like lobe and ending distally in a typical marsupial pouch-like expansion (Figs 36–37, 39), virga inversed V-shapaed, consists of 6–7 spines (Figs 36, 38)..... *C. lodscrozetae* sp. n.
– Tergite IX without such elevated dorsal hump (Fig. 52); base of anal point truncate (clearly visible in lateral view, Fig. 51); inferior volsella composed of 1 large swollen lobe (Figs 52, 57); virga typically horseshoe-like, composed of 3 spines.....*C. macunensi* sp. n.

Discussion

The nearest *Chaetocladius* species to the five diagnosed and described species include: *C. insolitus* for *C. castellae* sp. n.; *C. gracilis* and *C. antipovae* for *C. lencioniae* sp. n.; *C. dissipatus*, *C. holmgreni*, *C. egorych* and *C. aedeagolobatus* for *C. lodscrozetae* sp. n. Based on some specific characters found in the male adult of *C. macunensis* sp. n (shape of anal point, inferior volsella and virga), this new species can be placed near *C. tenuistylus* Brundin, 1947 (sensu Makarchenko and Makarchenko 2004, Fig. 10). Although some resemblance can be found between the five new described species and other related members of the *Chaetocladius* genus, the taxonomic position cannot be clarified until current comprehensive work on the genus is complete.

Worldwide there are actually about 79 known *Chaetocladius* species, which include the hitherto listed 69 species by Ashe and O'Connor (2012) and the recently described 10 species by: Makarchenko et al. (2017), Moubayed-Breil (2017), Moubayed-Breil and Dia (2017), Rossaro et al. (2017). Consequently, the updated previous list of 79 species is upgraded to 84, which currently include the five new described species in this paper.

Currently, only seven *Chaetocladius* species are known from Switzerland: *C. coppai* Moubayed-Breil, 2017; *C. laminatus* Brundin, 1947; *C.* cf. *longivirgatus* Stur & Spies, 2011; *C. melaleucus* (Meigen, 1818); *C. perennis* (Meigen, 1830); *C. piger* (Goetghebuer, 1913); *C. suecicus* (Kieffer, 1916). Consequently, the description here of the five new *Chaetocladius* species increases the total number in the genus to 12 known valid species for this country.

Geographical distribution of the five new described species is currently restricted to the two Alpine Swiss glacial catchments (Figs 66–68): upper catchment of the Rhône River and Muttbach streams; streams and lakes delimited by the Macun area. Type localities of *C. castellae* sp. n., *C. lencioniae* sp. n., *C. lodscrozetae* sp. n. and *C. muttensis* sp. n. are delimited by stenothermic

springfed rivulets located close to glacial streams (Rhône River, Mutt stream) and the upper Rhône catchment (central Switzerland, alt. 1800–2000 m). *C. macunensis* sp. n. only occurs in a high-alpine catchment in the Swiss National Park (Macun region, Eastern Swiss Alps, alt. 2550–2700 m).

It is of interest to note that none of the new described species in the present work is identical to any of those described recently from southern side of the Alps (Stur and Spies 2011, Rossaro et al. 2017). This may contrast with a previous statement that the faunae on the two sides of the Alps are similar (Reiss 1968). Nevertheless, it is not really surprising, as the Chironomidae still are quite incompletely known with new species being described continuously from various parts of the word, including from Europe.

Conclusion

The presence of the five new species in some high mountain Alpine ranges of Switzerland highlights the importance of some cold glacial enclaves, considered as hotspots of endemism, in the preservation and persistence of autochthonous and sensitive alpine relic species. Such species are considered as relevant biogeographically representative and their loss would be biologically indicative of the global warming and climate change.

Acknowledgements

Special thanks are due to our colleagues Patrick Ashe (Dublin) and Martin Spies (ZSM, Munich) for their constructive comments and suggestions, which markedly improved the manuscript. The authors express their thanks to Michel Sartori (Musée cantonal de Zoologie, Lausanne) for his kind assistance as well to Jade and Marie-Helene Breil-Moubayed for achieving the measurements of the leg ratios.

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